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THE AMERICAN GAS-LIGHT JOURNAL AND CHEMICAL REPERTORY

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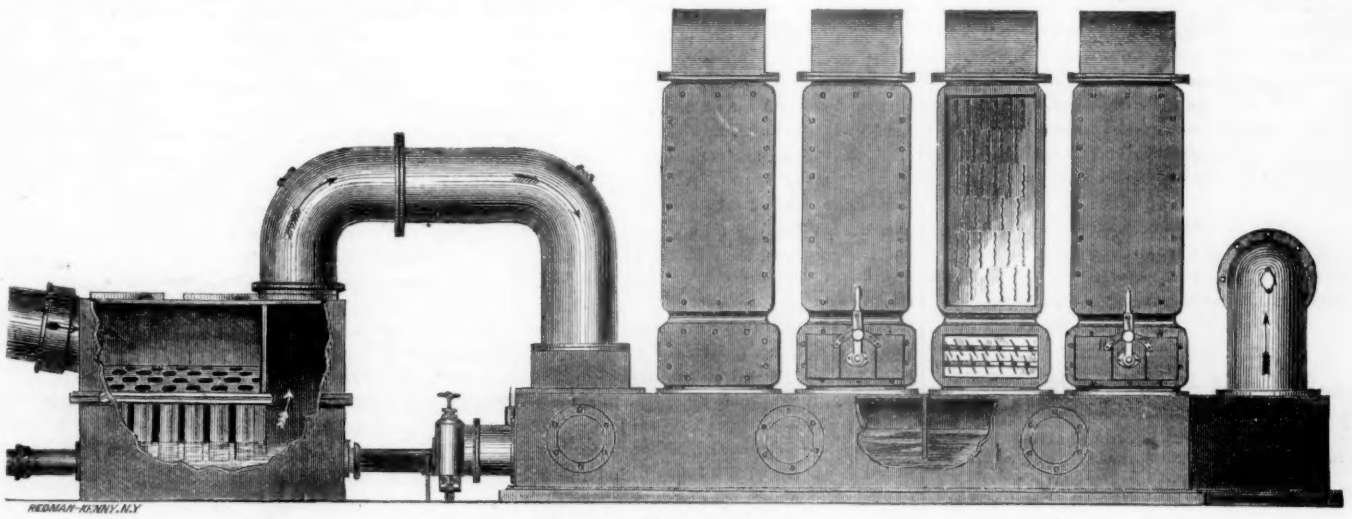


FRONT ELEVATION.

The New Gas Scrubber of the St. John and Rockwell Company.

The above cut represents the St. John and Rockwell Company's Gas Scrubber as now working, and has been successfully for over one year at the Harlem Gas Company's works of this city, to which the attention of all gas companies is particularly invited, and where every information will be cheerfully given.

It is from this Scrubber that the critical and searching investigation of Prof. Chandler has been made, which appears in this issue, as also the thorough investigation of Prof. Wurtz, which appeared in the last issue of this Journal.

The cut as seen is drawn to a scale of one quarter inch to the foot, and proves conclusively how very effective and thorough it is in its workings.

Since its introduction at the Harlem Gas Works, there have been several patents issued upon the Scrubber, covering all the essential points; also increasing the number of boxes, thereby removing every vestige of ammonia, tar, etc., etc.

In the next issue of this Journal an account will be given by Mr. St. John, of the great advantages of the Scrubber over any known process for cleansing and purifying gas; also as to what we claim and will guarantee to accomplish. S. O. ROCKWELL, Sec.

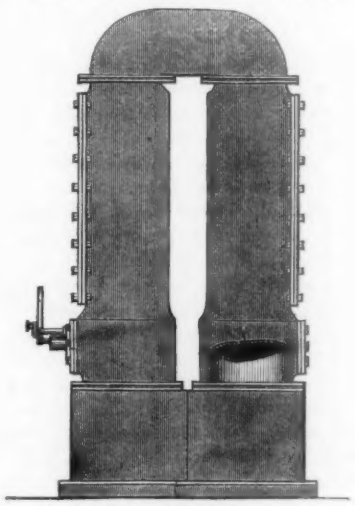
No. 59 and 61 Liberty street, N. Y.

REPORT OF PROFESSOR CHARLES F. CHANDLER.

To the St. John and Rockwell Company:

Gentlemen: I have the honor to report the following results of my examination of your process for dry scrubbing, or applying the liquid products of coal to the removing of the tar and certain other impurities of coal gas, in place of the usual process of condensing and washing.

The works of the Harlem Gas Company of New



END VIEW.

York, were placed at my disposition, and with my assistants I took possession of them, and superintended the work of gas making for the week from May 5th at 12 M. till May 12, 12 M.

All the operations were under our careful scrutiny, day and night.

We weighed the coal and coke, kept the record of the make of gas, tested the gas constantly by the photometer, determined the sulphur and ammonia contained in it, examined the purifiers when they were opened, and in fact noted every circumstance that would enable us to judge of the merits of the process under investigation.

Penn and Murphy Run coals were employed, which examined in the laboratory, gave the following results:

	Penn. Per cent.	Murphy Run. Per cent.
Moisture	1.700	1.574
Volatile Combustible Matter	34.865	37.105
Fixed Carbon	56.040	49.080
Sulphur	1.020	2.840
Ash	6.375	9.460
	100.000	100.000

From 121 to 126 retorts were in daily use—an average for the week of 125 1-6th. The coal employed during the seven days was

Penn	163,120 lbs.
Murphy Run	470,445 "
Total	633,565 "

The amount of gas produced was 3,082,600 cubic feet, equivalent to 4·865 feet per pound, or 10,897 feet per ton of coal. The coke weighed 423,767 lbs., or 1,496⅓ lbs. to the ton of coal, about one chaldron. The charges were of six hours duration.

The illuminating power of the gas varied from fifteen (15) to nineteen and nine-tenths (19·9) candles, and averaged seventeen and six one-hundredths (17·06) candles, by "Patent London" burner of Sugg.

The sulphur contained in the gas was twenty-three

and five hundred and eighty-six one-thousandths (23.586) grains in one hundred cubic feet.

The ammonia contained in the gas was two and sixty five one-hundredths (2·65) grains in one hundred cubic feet, which proves that your process of condensation is as effective for removing this substance as the old methods, which involved the use of large quantities of water.

No condenser, washer or scrubber of any kind was used; the gas passed from the hydraulic main directly to your apparatus, and thence to the purifiers.

At the close of the experiments the condensing apparatus was opened, and was found to exhibit no signs of clogging, although I was assured it had been in use since January.

The purifying material was the St. John & Cartwright mixture, consisting chiefly of brown hematite iron ore, with a thin layer of dry lime on top, one or two inches thick.

The purifiers required changing but twice during the period of the experiments.

These results are so expressive in themselves that it is hardly necessary for me to remark that they establish all that you have claimed for the process.

Nearly eleven thousand feet of seventeen candle gas, of good quality, from a ton of such coal, with such simple and inexpensive apparatus, is a result hardly to have been expected, and which fully confirms the theory on which your apparatus is constructed, viz.:—that the removal of tar and ammonia water from gas does not depend upon cooling—*i. e.*, condensation—but upon forcing the gas to come in contact with a surface possessing the power of catching and holding the minute suspended globules of tar and moisture.

I would say in conclusion that the gas was very clean and did not clog the purifier, and that the process proceeded quietly and regularly from the beginning to the end of the investigation Yours, etc.

C. F. CHANDLER, Ph.D.

New Processes in Proximate Gas-Analysis.

By HENRY WURTZ, of New York.

[Communicated in part, with Experimental Illustrations, to the AMERICAN GAS-LIGHT ASSOCIATION; October 22, 1874.]

Gas-Analysis, in the widest and highest sense of the expression; comprehending the proximate analysis of gaseous mixtures, natural and artificial, as well as the ultimate analysis of gaseous compounds; includes what have heretofore been unquestionably the most difficult and delicate, while also, when correctly viewed, the most fruitful and promising branches of laboratory chemistry. It is also quite just to assert of these branches that they have of late years been far too little cultivated by many chemists of the first rank. It is to this that I would attribute the fact that your own great and noble art of Artificial Illumination—to which I might add those of metallurgy and furnace operations generally—linger in a stage of empiricism not in accordance with the actual advancement of chemical science. It may safely be alleged that we are now learning far more, and more rapidly, of the liquid and solid products of retorts and furnaces, than of the gaseous products. This should not continue; and I venture to hope that the observations I have to offer may in some measure lead the way, and to some extent lay the foundation, for the more diligent application of known chemical principles to the practical investigation of gaseous mixtures and products of the chemical arts.

The class of methods known by the rather insignificant name of Eudiometry, had so great an impulse imparted to it a quarter of a century ago by the genius of the illustrious Bunsen, that gas-chemists have really seemed to me to merit since, in some measure, the reproaches cast upon the immediate disciples of Aristotle of old, who believed their great master had probed the depths of possible human wisdom, and therefore refused to interrogate Nature further. It is true that many of Bunsen's methods, apparatus, and manipulations in gas-analysis, will remain indispensable, and will stand as monuments to his fame; very little having been done since, except in the way of modification, by other chemists; but there are nevertheless cases and conditions often of great importance, where all so-called eudiometric methods fail to satisfy the practical requirements.

One such case may here be entered into as an example. This is the determination of *air*, as a contamination of illuminating gas. It is well understood that each single proportion per 100, of air, destroys at least six per cent. of the illuminating value of an ordinary coal-gas. It is not easy then to exaggerate the importance of this case. But, in a eudiometer 500 millimetres long, one volume per 100 of air is but one millimetre of oxygen. A variation or error o observation of a single degree Fahr. of temperature, or of ·061 inch of barometer, down or up, will either double or destroy this determination. But by the methods I have now to propose, one cubic foot of such gas will yield, in a form amenable to the balance, 1·18 grain = ·076 gram of oxygen; and 5 cubic feet, ·3815 gram.

Moreover, in eudiometric oxymetry, the introduction of potassic pyrogallol into the gas under investigation, is always of necessity preceded by that of potassic liquor or potassic hydrate, to remove carbonic acid; and if this potash be washed out with water, say with a minimum, of 20 millimetres (in a eudiometer of 500 mm.), of the latter, this water will always abstract some of the oxygen sought to be determined. At 60°F. = 16°C., 20 mm. HO can take up (Bunsen) ·59 mm. of O; or, in this way, as much as 59 per cent. of the oxygen (and air) sought may be altogether lost! I may add that, in working on coal-gas, the further possible, or at least supposable absorption, by this 20 mm. HO, of .29 mm. of N, .39 mm. of H, and .48 mm of CO gases– together with the .59 mm. of O—1.75 mm. in all—might vitiate the CO^2 determination to the extent of 0·35 per cent. of the whole volume, in excess; which, in a coal-gas purified by lime, would be a vitiation quite fatal to the value of the analysis.

Some eudiometrists may reply that they do not wash out the potash with water, before applying pyrogallol. If so, I must impugn their work on several other grounds:—for instance, will the film of potash liquor on the inner walls of the eudiometer occupy the same volume as a film of pure water? My own experiments have shown me that it will not. Again, either solid potash or strong potash-liquor desiccates the gas, thus introducing another very appreciable error. A conscientious original investigator, who tests all methods rigidly himself, will devise ways to mitigate, if not to eliminate some of these difficulties; but this does not meet the practical requirements of the case, for all are not competent to do this.

The above is cited as but one sample of the multitude of difficulties with which every really competent eudiometrist must admit himself to be environed.* Special and complex devices have not been wanting—many of them of great and permanent value—to lessen certain difficulties; but it has appeared to me that in those cases—including many of the most important ones, as, for example, illuminating gases, and gaseous furnace-products—in which the mixture to be analyzed is attainable in volumes practically illimitable; it would be well to try to cut loose from methods which are purely volumetric, and to devise such new ones as would enable us to deal with quantities that can yield ponderable products; thus appealing direct to that infallible criterion, the chemist, "Court of last resort," the balance.

In this attempt, I have already met with success sufficient to encourage me to put forth the results before the chemical world, confident that some things will be recognized in them worthy at least of being followed up and brought to a further stage of perfection. This further pursuit of these paths of promise, will be my own task; so far as it may be permitted to me.

The methods I now put forth are founded on the general principle of submitting a slow current of the gas to be investigated to the action of a series of agents, so selected and combined as to absorb and separate, in succession, each by itself, the different proximate constituents of a gaseous mixture, converting each into a solid or a liquid form, which can be weighed on a balance. About 1840, European chemists were using successfully methods of this class. One method, which arose at that time, out of their experiments in this direction, was that still in use in "Organic Analysis," for separating in distinct and weighable forms water and carbonic acid. Strangely, however, the capabilities of these methods seem to have been looked upon as very narraw and special, and they have passed almost out of view. At the present day it is probable that a majority of chemists would not have anticipated, in advance, much satisfactory success in the application of these modes of procedure to such complex mixtures as crude coal-gas, or a furnace-gas. My experience has, nevertheless, tended to an opposite conclusion, and I believe that I discern, in this direction, the only practicable road to complete success in the proximate analysis of heterogeneous gases.

[In this memoir, I will here say, I must confine myself mainly to illuminating gases. The handling by these methods of furnace-products will furnish subjects for future communications.]

In a crude coal gas, as drawn from the hydraulic main, over the retort-benches, the following main constituents may be enumerated, which it is highly important that a gas-chemist should be competent to separate and determine with precision:

1. Tar, suspended in the form of spray.
2. Water, in similar mechanical admixture.
3. Water, as vapor, dissolved in the gas.
4. Naphthaline (condensable).
5. Other condensable hydrocarbons.
6. Smoke and soot (with dust).
7. Ammonia.
8. Carbonic Acid.
9. Sulphuretted Hydrogen.
10. Carbonic Oxide.
11. Oxygen, that is; Intermixed Air.

Of these eleven proximate constituents, I have so far, succeeded in separating, with very satisfactory sharpness, Nos. 1, 2, 3, 6, 7, 8, 9 and 11; eight in all. besides some approximation to No. 4, the naphthaline in excess. No. 10, the carbonic oxide, is still a subject of experiment.

My success so far, is to be attributed mainly to the gradual attainment, by tentative experiment, of the following devices and manipulations.

First—Arresting suspended matter by means of empty dry flasks and straining through cotton previously *desiccated*.

Absorbing next, the ammonia, by means of reagents which act on no other ingredient.

Next, drying the gas with CaCl, which. NH^3 being absent, may now be done.

Next, taking up the sulphuretted hydrogen by a normal metallic salt, so selected or so managed as to give up no water or acid vapor to the desiccated gas.

Next using sodic hydrate to absorb the CO^2, with certain precautions described below.

Next, alkalized pyrogallol or other suitable agent, to absorb oxygen, arranged so as to lose no water.

In the case of illuminating gases—with some few others—the final (rough) measurement of the gas is then made at an observed temperature by a gas meter; if with a dry meter, directly: if with a wet meter, after saturation with moisture at the temperature of melting ice.

In the latter case, of a wet meter, the amount of final moisture in the gas is determined by a reiterated desiccation with CaCl.

* I may be excused for here introducing the remark that I myself have endeavored to do my share with other gas chemists towards the emendation of Bunsens system of eudiometry. My own efforts have been generally in the direction of simplification, and more especially to attain (what I have always deemed) the great desideratum of a reduction of the needful amount of quicksilver to a minimum. I now use simple devices and manipulations which enable me to accomplish all the essential work of eudiometry with, at the most 10 lbs., and chiefly with not more than 5 lbs. of the liquid metal. These will soon be submitted to the chemical world.—H. W.

The whole process is finally completed and the separations rendered as sharp as may be, by a process of distillation, either at the ordinary or higher temperature in a current of the same gas analyzed, that has been previously subjected to the same or similar treatment and thus freed from all the ingredients to be separated from each other.

After final weighings, the *correct* initial volume of the gaseous mixture is calculated by certain formulæ derived, as specified below, from the crude meter-indications and the final weighings.

I shall now proceed to an attempt to explain simultaneously, to save space, the details of the methods as applied to each constituent, and those of the construction, preparation and arrangement of the different pieces of apparatus, as connected and represented in the figures.

I. Analysis of Crude Gas, in the Gas-House, before Purification.

The mechanically suspended Tar and Water. The joint devices for arresting these two substances, in the first instance, are shown in Fig. 1, letters A to F inclusive. A indicates an inch thick soft-rubber cork, with two perforations, occupied respectively by

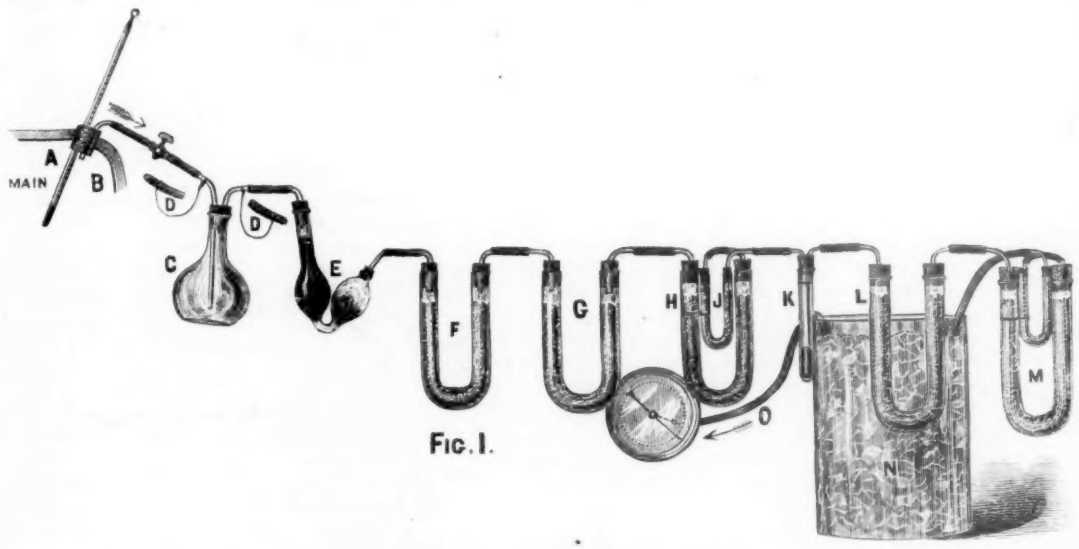


Fig. I.

Train for the Analysis of Crude Gas, from the Hydraulic Main of a Gas Works, Etc.

[Note.—Between G and H an additional tube, precisely similar to G, charged with *chloride of calcium*, is employed. which, for simplification has been omitted from the figure.

a thermometer and an eduction-tube bent at a right angle, inserted into an aperture bored through the wall of the hydraulic main or of any other main in the works. This eduction tube must at once descend, to allow liquids to flow into the flask, and must have a stop-cock in it. The first member of the train is an empty dry thin glass flask C, which collects almost the whole of the spray, aqueous and tarry. DD are two stoppers for closing C hermetically, constructed of pieces of rubber tube closed at one end by short sections of glass rod. The bent wires by which these are permanently attached to the flask had better be of iron than of copper, as they are to be weighed with the flask, and the latter metal is quickly blackened and may be slightly changed in weight by the sulphide of ammonium that pervades the atmosphere of the gas-house. In a permanent apparatus, for nicety, platinum wires had better be used. Copper wires, however, used here, and in other parts of the apparatus, may be protected pretty well by coating with collodion, or even with a film of paraffine [All the brass stopcocks I use in these and all other operations with sulphuretted gases, I prefer to plate, inside and out with nickel; which protects them perfectly against sulphur. This nickel-plating, every gas-chemist will find it well worth his while to perform for himself, as it is *very* easy to accomplish, in case of brass and copper surfaces, with slight practice. I propose publishing a note which I think will lead any laboratory worker to success in his first trials.]

These trains of apparatus are probably most conveniently set up by being suspended to a strong wire—best of soft copper—stretched tightly between two convenient points of attachment. To make this wire tense or "tant," it had better be in two pieces, attached first at the extremities, then twisted together strongly and warily with pincers at the point of meeting. The tubes are hung on inverted V-shaped (A) wires bent into hooks below. These, for simplicity, are not figured. All the rubber tubing used as connectors, I wash laboriously, internally and externally, in a rapid current of water, with hard rubbing between the hands, until absolutely clean, then rub dry, and lubricate, within and without, with thick syrupy glycerine, The excess of this being wiped off, the tubing is found permanently more flexible, far less liable to abrasion of surface, more easily slipped over ends of glass tubing, and, above all, has its capacity for absorbing certain constituents of the gas reduced to a minimum. All the corks should be rubber, scoured and glycerated superficially in the same way. The cork at A—owing to the heat and actual contact with tar—and, to a less extent, the cork of flask C, are somewhat penetrated and softened, so that A gives out, after being used a number of times. The others last indefinitely.*

E and F are stuffed, uniformly, but as loosely as practicable, with cotton, which is best inserted and gently packed down, in successive small wads, picked out before insertion. The bulbous pattern, like E,† may present here some advantage, but it is not at all essential. Its use, as photographed in this case, was in order to bring down somewhat the level of the rest of the train. I have used, and prefer, a compound cotton apparatus, or two tubes of the size of F, united by a twisted wire in the manner of A in Fig. 4. These can be weighed together conveniently.

Even in case of a gas that has passed through condensers and scrubbers, it seems necessary to use two tubes of cotton. In one actual series of analyses, of unpurified coal-gas before and after having passed the scrubbers and condensers, the second tube F, increased, on an average, in weight (all moisture having been removed) from the uncondensed gas .128 grain, and from the condensed .072 grain, per cubic foot of gas passed, up to 7 cubic feet. The main consideration here is the initial *pressure* at command, of the gas. If the customary exhauster is employed in the gas-works, and kept at work during the analyses, the pressure between the exhauster and the retorts may be found so low that a train attached between these, may not admit of more than one cotton tube, and even this packed as loosely as possible. At points beyond the exhauster, however, this trouble seldom occurs; it having been necessary indeed, in some such cases, with unpurified gas, to partially close the cock in the eduction tube, to bring down the rate of flow through the train to about one cubic foot per hour, which it should not in most cases exceed.

The Ammonia.—In order that we may employ, for dehydration, the highly convenient, powerful, and reliable agent, chloride of calcium, it quickly became apparent to me, in my earliest experiments, that the ammonia must first be abstracted from the gas; and my first efforts were to decide upon the proper agents that could be used, in solid form, for this absorption. One of these I have so far sufficiently tested, by quantitative as well as qualitative experiments, to demonstrate its entire applicability to this use; namely fused *potassic bisulphate.* It is proper for me here to state that the earliest preliminary experiments with the bisulphate, were made, at my suggestion, in the course of an investigation carried on jointly by Prof. B. Silliman,* Dr. S. D. Hayes and myself; in which we desired to absorb the ammonia of crude coal-gas. We all became convinced, I believe, that potassic bisulphate had the power to take out *qualitatively* the H^3 from Ngas; but the precautions essential to success, in a quantitative way, have been since worked out by myself alone.

The mode of preparation of the bisulphate is by simply cracking in a mortar to the average size of wheat-grains, and removing the dust and finer particles by a sieve of eight holes to the inch. The dust is very painfully irritating and injurious, and its inhalation must be avoided, if possible.

[Though many chemists seem somehow to have acquired the idea that bisulphate of potash possesses more or less *deliquescence*, it in reality has none of this quality whatever, and it is not even hygroscopic, to any remarkable extent.]

It must not be supposed that the bisulphate takes up ammonia as NH^3, which would involve a very important error. The compound formed, as desiccated for the final weighing, is the double sulphate of potash and oxide of ammonium. The factor *am* in the equations below must be obtained, from the increase of weight, by multiplying by a coefficient = ·70833. And it may here be remarked that a part of another factor *we* comes likewise from this increase of weight, through multiplying it by ·29267. This ammonia-tube is lettered T.

The Water.—Chloride of Calcium for absorbing this, comes next in our Fig. 1 train, though, as it would be merely a duplicate of G, the CaCl tube has been omitted from the cut. I prefer—after trying many preparations—a *fused* chloride, assuring myself, above all, that it is free from every trace of causticity, and crack it up to the size of small peas, sifting out all that passes a sieve of six holes to the inch. For the small CaCl-tube J, the one in M (Fig. 1), and J and L in Fig. 4, I find it desirable to crack but little, if any, smaller; to avoid risk of obstruction.

The Sulphuretted Hydrogen.—For this constituent I have tried several absorbents, but none as yet that answers, on the whole, so well as common crystallized blue vitriol, cracked and sieved to wheat-grain size.

* All these corks should be of the *best* quality made. Many in the American market are very poor—indeed useless for this kind of work. I procure mine from John N. Elmore (the successor of Quettier) at 193 Greenwich street, New York; who will also supply, or have made, the different sizes and patterns of U tubes, etc.

† I may say here that E, as shown in the cuts, was in the condition left after having been used, and in drawing from the photograph, an attempt has been made, none too successfully, to reproduce the shading of the condensed soot.

* Prof. Silliman has also since worked by himself on this or a closely related subject, and made a communication to the National Academy, at the late Philadelphia meeting, to which I would refer. Prof. S; I believe experimented chiefly on the utilization of crude commercial bisulphates, generally of soda, called "salt-cake" in commerce, for the technical extraction of ammonia from gas.

As in desiccated air it slowly loses some of its water (Graham found that in fine powder, over oil of vitriol, it lost in seven days 3 of its 5 water-equivalents) I add a small CaCl tube, which is of course weighed with it in all cases. The test-tube K, containing a a slip of lead-paper belongs (qualitatively) with the cupric-sulphate tube H.

With crude gas from highly sulphurous coals it may sometimes be prudent to duplicate this member of the train. Of course the small CaCl tube J need be added only to the second one. The increase of weight in this member is of course HS. If to be calculated as simple sulphur, as sometimes required, it must be multiplied by .9471.

The Carbonic Acid.—The agent which combines, for this absorption, the greatest advantages by far, is that form of sodic hydrate now so common in commerce, cast into pencils, and labeled "soda by lime." In this class of operations the weight of CO^2 to be absorbed is often very large. In ten cubic feet of crude coal-gas containing 2 per cent. by volume of CO^2, there is about 172 grains by weight of the latter, which requires for absorption (if normal carbonate be formed) near 315 grains of sodic hydrate. Although some bicarbonate is usually formed, yet the absorbing surface required is large. Potassic hydrate, prescribed in the books, is wholly out of the question for these methods. The solubility of KO,CO^2 is so great, especially as much heat is always developed during the CO^2 absorption, that the water of the hydrate serves to melt the mass into a magma and quickly to obstruct the flow. In cases where mere abstraction of CO^2, without weighing, is the object, one large tube containing 10 or 12 ounces of sodic hydrate—as in H, Figs. 2 and 3—may be employed; but in the case under consideration, two tubes must be used, containing each 5 or 6 ounces, to reduce within conveniently weighable limits. These are here lettered L and M.

The soda-pencils are cracked up, a few at a time, by gentle blows in a mortar, to lengths of from .5 to 7 inch. This is very rapidly and easily effected; but still a film of moisture is absorbed; and I have found that desiccated gas will then take up from it a trace of water. The precaution is therefore taken to append a small CaCl tube to the second of the two, M. This may be avoided if the Preparatory Train, Fig. 2, be employed to dry out these soda-tubes, before their initial weighing.

The Meter and the Measurement Thereby.—This most essential operation of all, is effected with every precaution to insure known conditions of the residual gas. In the case represented in Fig. 1, it is to be understood that a dry meter is used to measure the gas as absolutely freed from moisture, and at, or as close as possible to, the temperature of melting ice. Within N, filled with cracked ice, is coiled some feet of rubber tubing—well *glycerated* internally—and the meter is enclosed—leaving the dial exposed—in an outer casing, not here shown, filled with feathers, or better, with *ice*. In an emergency, muffling the meter in blankets may be resorted to.

The meters used must of course be most carefully tested and their average errors determined and taken note of. Space cannot, unfortunately, be here spared to explain the modes of effecting this. As it may often be necessary to use wet meters, like those usually found in photometric rooms, I have represented in Fig. 4 a modified mode of measurement, which admits of such use. Here also, the whole meter, except the dial, ought to be protected, as before, from extert nal warmth.

II. Of the Preparatory Train. (Fig. 2.)

This is employed in the initial drying-out of the apparatus, preparatory to the first weighings; and also for the final completing of the separation preparatory to the last weighings; in the latter case, by the distilling or transferring over, in a current of pure dry gas, of the liquids that condense, by mere refrigeration aed adhesion, in the first tubes.

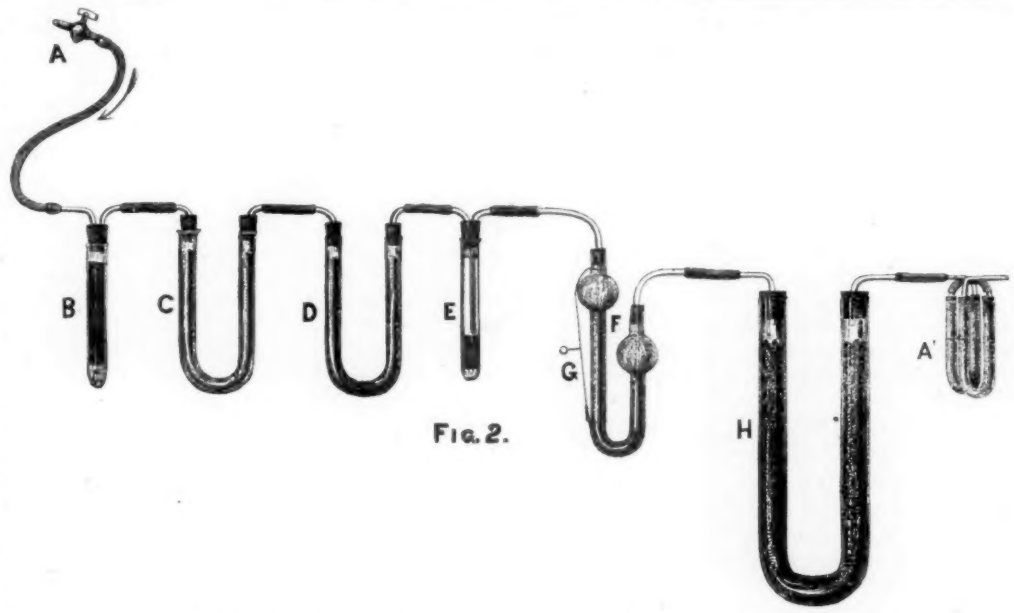


Fig. 2.

Supplementary or Preparatory Train; Both for Preliminary Preparation of the Trains for Analysis, and for Completion of the Processes Therein.

It is made up as follows: Stop cock A, in an induction tube from any service-pipe bringing street-gas; test-tube B with inlet tube passing to its bottom, which contains a strip of turmeric paper, to indicate (qualitatively) ammonia; two U-tubes C and D, containing respectively granulated fused bisulphate of potash, and granulated blue vitriol; a second test-tube E, containing slips of both turmeric and lead-paper, to demonstrate the complete removal by D and E of the HS and NH^3 (the latter by comparison with the turmeric paper in B); aCaCl-tube F; and a sodic hydrate-tube H (of large dimensions, as shown, in cases where the street-gas, through iron-purification or otherwise, contains very much CO^2). [B, in this train, is not at all essential.]

In this figure the Preparatory Train is represented as attached to the first compound member (marked here A') of the train for analysis of purified gas, shown in Fig. 4. In Fig. 3, H represents the final member of the preparatory train; showing its connection with the train in Fig. 1, during the distillation preparatory to the final weighings.

It may be stated that this preparatory train being required only to furnish a current of gas free from moisture and impurities, it is obvious that the current that issues from one analytical train while in operation, is suitable for the preparation, for either initial or final weighings, of another analytical train, and that this circumstance will at times be available, and lead to saving of trouble in transportation and erection of apparatus.

Another important point of practice with the preparatory train, demands a few words. Its union with the analytical train represented in Fig. 1, makes a long and very tortuous passage for the gas, which necessitates an important *pressure* to force a rate of flow sufficient for rapid work. This is very liable to cause difficulty, with street-gas; particularly during the mid-day hours. It will therefore often be advisable to arrange so as to conduct preparatory operations during the night-hours. Cases occur in which special expedients may be necessary, to procure a sufficient flow. A small gas-holder, when available, may be used. The pressure in the mains between the exhauster and the purifiers, will always be ample to force one or even two cubic foot per hour, through almost any length of (unobstructed) train; but in this case it must be remembered that the preparatory train should possess an extra size and power, and be properly proportioned, to take out the large proportions of impurities present; for if a preparatory train left working with an analytical train overnight should become fouled, of course the whole apparatus would be liable to be rendered useless. and the whole time and labor be lost.

It may be scarce necessary to suggest that for these preparatory operations, coal-gas is used only for convenience. With a holder, or an aspirator, a stream of *air*, similarly freed from HO, NH^3, CO^2, etc., is generally equally applicable, and when the pressure has to be assisted, we may, in most cases, just as well use air, if we have the appliances.

III. Of the General Manipulations with Crude Coal-Gas.

In addition to the details which have been given when describing singly the members of the train in Fig. 1, further explanations are needed, especially with regard to the application of the preparatory train thereto. In the preliminary preparation for the *initial* weighings, it is unnecessary, with the arrangement as here represented, to attach more than the first four pieces, to and including the bisulphate-tube G: for reasons which will be obvious without explanation. Some five or six cubic feet of gas transmitted from a preparatory train, will dry out these first four members sufficiently to allow of correct weighing. This will be accomplished by setting and keeping the apparatus at work during one night, say from 5 P. M. till 8 A. M., or 15 hours, at the rate of about three or four foot per hour. The rate of flow is readily regulated by a few observations, of ten minutes each, of a meter at the tail of any train. A little practice enables the rate to be judged of closely enough, by the size of the flame burning from a small straight glass tube at the tail of the apparatus, as shown in Fig. 4.

The preparation for the final weighings is here the important part, and indeed the only troublesome part of this analysis. Fig. 3 represents, as aforesaid, the mode of attaching the preparatory train to Fig. 1, for this final operation, or rather succession of operations. D here represents a new tube introduced at this time, which is an ordinary form of CaCl tube, but having its smaller extremity bent at an obtuse angle, as shown, and which contains, near its upper end, a slip of turmeric paper, and has, moreover, running through it from end to end, and projecting an inch at each end, a *small flexible copper wire*; the object of which latter is to clear a passage through the crystals of naphthaline which condense in this tube at a subsequent stage of operations.*

* This wire should have shown more distinctly in the cut, but this is only one of several unfortunate defects in these cuts.

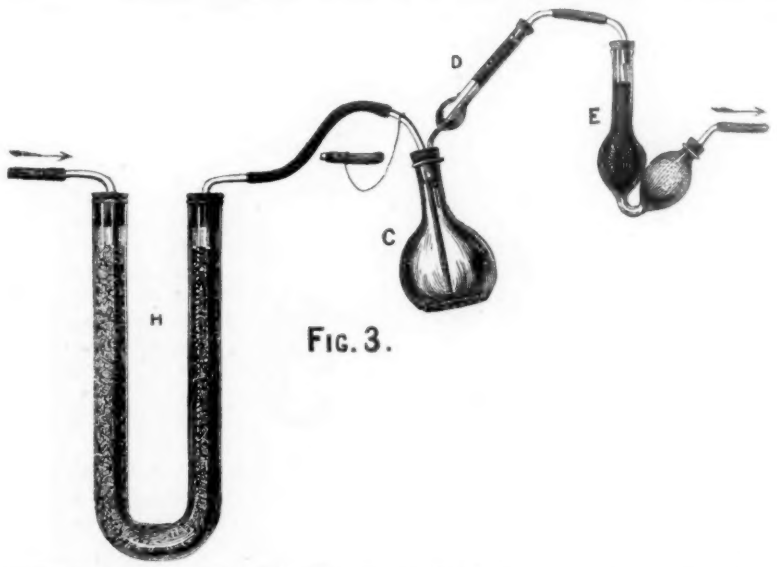


FIG. 3.

SUPPLEMENTARY ARRANGEMENT FOR COMPLETION OF PROCESS IN THE TRAIN SHOWN BY FIG. 1.

After this disposition of the apparatus has been made—D having been of course *weighed* with its appendages; and the jar of ice N (which is no longer of use) removed, the meter being connected directly with M—the first step is to distil over, at a very low temperature (unless saving time is important, at ordinary temperature) in the current of gas from the preparatory train—which generally in this case may flow even as rapidly as two feet per hour—all the volatile ammonic carbonate and sulphohydrate that has condensed in the flask C and cotton tubes E and F. The volume of gas required to effect this may be double (or even more) that from which the liquid was condensed. It ought to have been stated that the total amount of crude gas analyzed by this apparatus should not exceed ten cubic feet. This volume is within the limits of manageability, but generally somewhat less is probably advisable. With a rapid current of gas, this complete transfer of the volatile ammonia-compounds will be found to have been effected during 15 or 18 hours; but sometimes more time is required; and it is better to allow 24 hours for this part of the process. If an attempt to hasten it is made, by immersion of the flask in warm water, constant watching is necessary, as *naphthaline* then enters upon the scene, and may at once clog up all passage. The complete transfer of the ammonia is indicated by the return o the slip of turmeric-paper to its natura color. As, in my experience so far, this liquid *always* contains *chloride of ammonium*, and possibly sulphite and other non volatile ammonia salts, those who wish to transfer *all* the ammonia to the bisulphate-tube F, must introduce into the flask a weighed quantity of dry hydrate of soda.

When the ammonia-transfer has been completed, the flask C is immersed—the gas-current being continued—in water sufficiently hot to volatilize the naphthaline, which will condense in crystalline form, together with water, in the tube D. The wire running through D now comes into play; and, in fact, without it, naphthaline would here become as great a cause of difficulty as it often does in the distribution of coal gas. When clogging occurs, the gas-current is stopped, the rubber connector between D and E detached, and the wire moved up and down or twisted round. With careful management, two hours work and some two feet of gas from the preparatory train, will suffice to transfer the naphthaline to D, which is then detached and weighed again. To remove the intermixed water from the naphthaline, the lower end of D is stopped, the cork and tube removed from the upper end, the wire coiled within, and this upper end connected by a wide short rubber-connector with the open end of a test-tube containing some granulated CaCl. When dry, the cork and tube restored, the stopper removed, and the weight again ascertained; the variation now from the first weight is the naphthaline, so far it can be saved by this mode; which of course is imperfect, but is the best that I have so far succeeded in devising.*

The flask C, still containing tar and water is then removed likewise from the arrangement—the stoppers DD (Fig. 1.) being applied—and then H of the preparatory train is connected directly with the first cotton-tube E; the gas-flow being resumed. Some five feet more of dry gas may be now required to transfer all the moisture to the CaCl tube between G and H (omitted from the cut). The water and tar in the flask C must be separated by careful distillation at a very moderate temperature, and in estimating the weight of the residual tar, account must be taken of the sodic hydrate that was added, as above, to eliminate the fixed ammonia.

The point at which the whole train becomes dry and ready for the final weighings, is readily perceived by a practised eye. One indication is a faint superficial whitening of some unaltered blue granules (if any) of cupric sulphate in the tube HJ. Several other indications might also be cited.

IV. OF THE GENERAL MANIPULATIONS WITH PURIFIED COAL-GAS.

Fig. 4 represents a very complete train for this purpose. As the suspended matter here is absent or trifling in amount, and the ammonia usually very small, A represents a combined arrangement for taking up both these. The first or right hand U-tube is loosely filled with cotton, the second one with granular bisulphate. E contains two slips, of turmeric and red litmus papers, to verify the perfect efficiency of the bisulphate. F contains granulated cupric-sulphate crystals. G is CaCl. H is sodic hydrate, with a small CaCl-tube appended. The arrangement KL, for determining oxygen, requires special explanation. K contains glass beads or broken-up glass rod, wet with a concentrated solution of pyrogallol in previously-boiled water. L contains CaCl. As, in order that the pyrogallol should take up the oxygen, there must be an alkali present, the following special course is adopted for preparing KL for initial weighing and introduction into the train. K is immersed, L being detached for the time, in snow and salt; and connected with a flask like C in Fig. 1, containing some of the strongest liquid ammonia. A current of common street gas is then directed first into the ammonia-flask, then through K. The former is warmed, and the gas, as it issues from the latter, lighted. The point of saturation of the contents of K with NH^3 will be indicated by a change in the character of the flame. The ammonia-flask is then detached, K being simultaneously—to prevent ingress of air—attached to J, L replaced, and the whole put in position.

A, in connection with E, is also dried out before initial weighing of the former, by a current from the Preparatory Train; this operation being greatly accelerated in this case, by immersion of A in the boiling water in B, which is raised up and hung, for this purpose, on the little wire pothook D. It is to be observed that the two tubes in A are weighed separately, and not together; and to avoid hygroscopic moisture, cooled and enclosed while weighing, in close boxes of sheet-brass or tin. The members of this train F, G, H, and P require no preparatory desiccation before

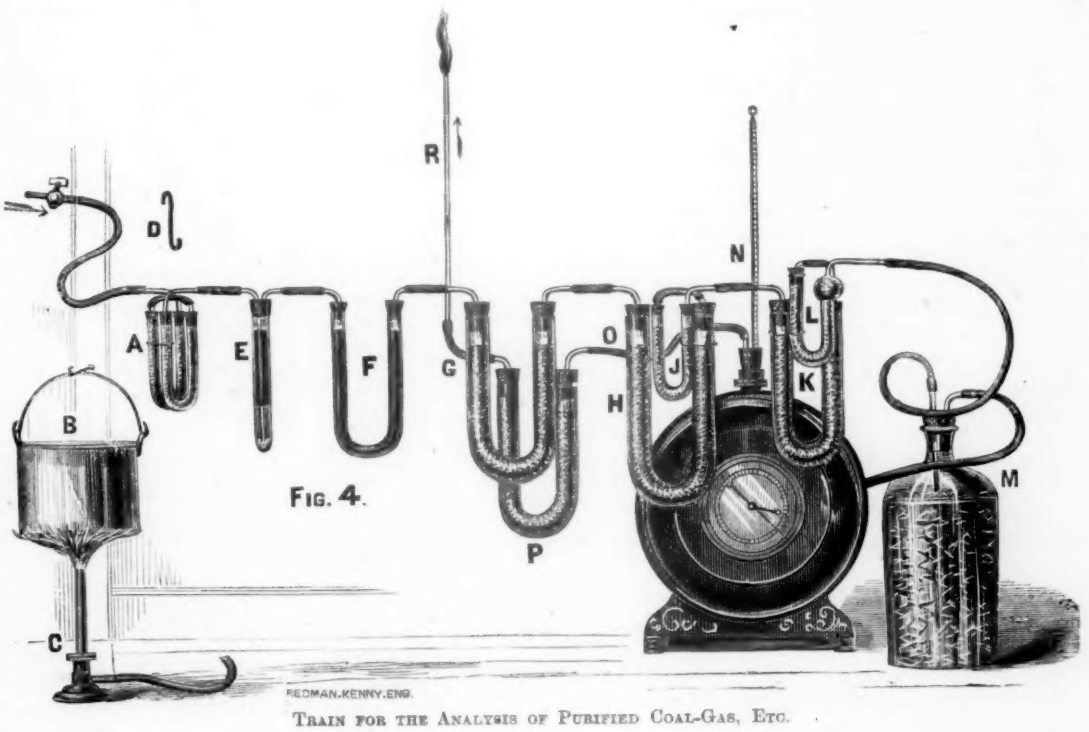


FIG. 4.

TRAIN FOR THE ANALYSIS OF PURIFIED COAL-GAS, ETC.

* Since the above was written, I have discovered that a very appreciable amount of naphthaline condenses, and remains throughout the final desiccation, in the cotton-tubes E and F, and has therefore been rated as solid matter mechanically suspended.—H. W.

weighing. After the whole train is put in action, during the actual analysis, should it be practicable to *watch* the apparatus during this stage, A may be *kept* immersed in the hot water in B, which will save subsequent expenditure of time in preparation for the final weighing. K must be watched from the first, and if it turns brown very rapidly—indicating *much* oxygen present—the current must be stopped when the meter has shown about one foot flow, and KL taken out to be weighed: resuming—after recording the meter—with a direct connection from J to M. This, because it may not be safe to trust K for more than one foot of a gas *largely* contaminated with air.

The usual rate of flow advisable, if attainable, with this train, is about one foot per hour; and the whole amount of gas analyzed should not be ordinarily more than ten cubic feet. This does not necessarily apply to the NH^3 and HS determinations, however; as in a well purified street-gas the amount of these in ten feet only might be scarcely appreciable. Therefore, after some ten feet has passed the meter, the latter having been read and recorded, direct connection should be established from F to M, the intervening members being thrown out. The flow may then be kept on through A, E, M, the meter, and P, even up to 50 or 100 feet, or until the registered volume is judged sufficient for these two constituents.

In this case, unlike the operation with the crude gas, no general distilling or transferring process is required before the final weighings. It is only essential that A should be free from condensed moisture at the close, by reason of immersion in B; or that it should be subsequently freed therefrom, by means of a dry gas-current through and from the preparatory train.

V. Of the Dimensions of the Apparatus, Etc.

The sizes and weights of the different pieces of apparatus must not be left unexplained.

Flask C is of one pint capacity. It is convenient to have at least four different sizes or patterns of U-tubes. The largest, represented by H in the preparatory train, is about 13 inches high, 1.1 inch internal calibre and 2.25 inches between the limbs. The second size is the most useful size, the corresponding dimensions being about $8 \times .9 \times 2$ inches, and is exemplified in Fig. 1, by F, G, H, L, M and the omitted CaCl.tube; and in Fig. 4 by G, H, K and P. The third size, C and D in Fig. 3 and F in Fig. 4, may be $6.5 \times .6 \times 1.9$.; and the smallest, represented in duplicate in A, and by J and L in Fig. 4, also by J and in M in Fig. 1, is about $4 \times .4 \times .75$.

The relative proportions of different members of a train to each other, are worthy of careful consideration, in planning an investigation; and much time and labor may often be thus saved. These proportions will differ with the conditions and with the nature of the gas, very largely.

For convenience in weighing, wires may be attached, as has been shown in the cuts in one case only—the CaCl-tube GF in Fig 2. As before stated, these wires, unless of platinum, are objectionable in the atmosphere of a gas works; and the tubes can just as well be simply laid across the pan of the balance. The balance should be capable of bearing safely a load of at least 300 grains or a little more, and indicating one milligram; that is of turning perceptibly with the 300,000th of its load.

One of the worst obstacles to accuracy in weighing large glass apparatus delicately, being the well known attraction of glass for moisture, I have adopted, as hinted before, a very valuable device; simply to provide thin polished brass, or tin cases, closing tightly, but *not hermetically*, suited in size to different sizes of tubes; within which the latter are shut up while warm and dry.

VI. Of the Calculation of the Results.

To obtain from the observed volume, as per meter, the true initial volume of the mixed gas and spray operated on, requires some calculation. Taking first the most complex case, that of a crude coal-gas from the hydraulic main, we shall have the following

FACTORS.

		DENSITIES.*
The observed volume, in cubic feet and decimals;	which call v.	
The final Fahr. temperature of the gas;	which call t°.	
The weight of liquid tar, in grains;	which call Lt.....	(Water=1)= 1·25
The weight of liquid water, in grains;	which call Lw.	
" " initial watery vapor;	which call wv**.....	(Air=1)=0·6220
" " gaseous ammonia (NH^3)	which call am.....	=0·5896
" " " sulphuretted hydrogen;	which call s.....	=1·1749
" " carbonic acid	which call c.....	=1·5202
" " naphthaline vapor	which call n.....	=4·5760
True volume sought, in cub. ft., at 60° F.	call V.	

The constants required in our calculation are:

1. The coefficient of dilatation of coal gas for the Fahrenheit degree. I adopt $\frac{1}{491\cdot9}$

2. The number of grains of pure water in a cubic foot, at 60° Fahr., which I make 436320.

$$(A.)—V=v+\frac{60—t^\circ}{491\cdot9}v+\frac{Lt}{436320\times\text{dens}\,Lt}+\frac{Lw}{436320}+\frac{wv}{565—\frac{(60—t^\circ)\,565\,\text{dens}\,wv}{491\cdot9}}-\frac{wv'}{565—\frac{(60—t^\circ)\,565\,\text{dens}\,wv'}{491\cdot9}}+\frac{1}{\frac{(491\cdot9—60+t^\circ)\,565}{491\cdot9}}\left(\frac{am}{\text{dens. }am}+\frac{s}{\text{dens }s}+\frac{c}{\text{dens. }c}+\frac{n}{\text{dens. }n}\right);$$

which on interpolating the density figures above, may be reduced to—

$$(B.)—\quad V=1\cdot12198v-\cdot002033t^\circ v+\cdot000002292\left(\frac{Lt}{1\cdot25}+Lw\right)+\frac{wv—wv'}{522\cdot134+\cdot71443t^\circ}+491\cdot9\left(\frac{am}{143876\cdot256+333\cdot124t^\circ}+\frac{s}{286703\cdot2+663\cdot82t^\circ}+\frac{c}{370964\cdot525+858\cdot9t^\circ}+\frac{n}{1115187\cdot4+2582\cdot05t^\circ}\right).$$

In the case in which t° equals 28° F., as when the final temperature is reduced quite down to that of melting ice, we may express it thus:

$$(C.)—V=1\cdot065065v+\cdot000002292\left(\frac{Lt}{1\cdot25}+Lw\right)+\frac{wv—wv'}{542\cdot14}+\frac{am}{311\cdot45}+\frac{s}{620\cdot65}+\frac{c}{803\cdot06}+\frac{n}{2414\cdot1}$$

In the case of purified illuminating gas, as from street mains, in which the suspended tar and spray should be, and ordinarily are inappreciable, the second right hand member of the equation (C) disappears, as also the last factor representing the condensable naphthaline; and if, in addition, the gas has been measured dry, by means of a dry meter at the tail of the train, so as to eliminate wv', we have (omitting also an inappreciable fraction in the first factor) the simplest case of all;—

$$(D.)—\quad V=1\cdot0651v+\frac{wv}{542\cdot14}+\frac{am}{311\cdot45}+\frac{s}{620\cdot65}+\frac{c}{803\cdot06}.$$

3. The number of grains of dry air in a cubic foot, at 32° Fahr. equal 565, according to Regnault.

As to the first, Ph. Jolly has recently given (*Chemisches Centralblatt* for 1874, p. 241; from Poggendorf's *Annalen*) new determinations, which, for Fahr° degree are

for H gas,	·002031
" CO^2 "	·002059
" Air "	·0020394†

As coal gas is almost half hydrogen, I have adopted $\frac{1}{491\cdot9}$ ·002033, which equals:—

For calculating the third constant, I have adopted as a basis a figure kindly calculated for me by Prof'r A. M. Mayer*, directly from the original determination of Regnault, for a litre of dry air under normal tensions, equal 1·29278 gram. Cooke's Chemical Philosophy gives this figure equal 1·29319 gram.

From Mayer's figure I get, closely enough, for one cubic foot air, at 32° Fahr. 565 grains. In the most complex case of all, as in Fig. 4, when a wet meter is used, and the gas measured with a certain content of aqueous vapor, afterwards determined by means of the CaCl tube P,; we have, in this weight, still another factor, wv'.

The following crude expression may now be first jotted down: (See below.)

The correction for *Atmospheric Pressure* has not been introduced into the above expressions, as it is independent thereof. In exact work, the barometer must of course be observed at short regular intervals, and V should be further corrected by reduction to the standard pressure of 30 inches or 762 mm This is very simple. Calling the volume as thus corrected V', and the mean of the barometric observations P. Then—

$$V : V' :: 30 \text{ inches} : P;$$

the volumes being inversely as the pressures; and—

$$V'=\frac{P}{30}V;$$

or, to reduce to an easily-remembered rule; multiply the whole of the right hand side of the above equations by

$$(\cdot03333+)P.$$

To the above discussion, it seems proper to append the remark, that the data determined by it, while necessary to the gas-chemist, are not indispensably needed by the mere practical expert; who may be more concerned to refer the proportions of the constituents, as found, merely to the volume of *purified* gas, brought to, or near to, normal conditions of tension and moisture. This is a simpler affair. For the bottle of broken ice in the above train, Fig. 4, I substitute, in this case, a similar one filled with *clippings of clean sponge saturated with water*, to serve the double purpose of bringing the gaseous current both to the temperature of the air, and to the maximum content of aqueous vapor correspondent thereto. If this be accurately enough accomplished, the direct reading of the meter, whether the latter be wet or dry, will be the required volume; subject only to the barometric correction above specified. The final

---

* The densities adopted for NH^3, HS and CO^2 are the theoretical ones, employed by Bunsen in his Gasometry. Other authorities differ perceptibly about all these. The density of aqueous vapor adopted is very close to Regnault's figure. Bunsen used .62205.

** It must not be forgotten that an addendum to wv is derivable from the final weighing of the bisulphate of potash tube.

† The figure of Regnault for this constant for air is almost the same as this; that of Magnus is a trifle lower. For Fahr. degree—

Regnault ·0020389, or $\frac{1}{490\cdot46}$

Magnus ·0020377, or $\frac{1}{490\cdot75}$

* Prof. Mayer remarks that he found a slight error in Regnault's own reduction of his observations.

CaCl-tube is then not needed, though it might still he used as a check upon the process, and will give a general and *precise* datum from which the gas may be calculated to any standard of temperature and moistness.

[The unexpectedly great space that has been occupied, in attempting to specify and explain these methods with the fullness that I have deemed desirable, has still not admitted of my noticing a number of interesting and important points, which must therefor be brought in, if possible, in future communications in continuation of the subject.—H. W.]

Chemical Repertory.

No. 125.—January 16, 1875.

EDITOR—HENRY WURTZ.

CHEMICAL EXCERPTS.

1324. Petroleum in North Germany.—The discovery of petroleum springs on the Luneberg Heaths in Northern Germany promises to convert this once barren and apparently unavailable tract into what might by comparison be designated as an El Dorado. Borings were made at Oberg by Hanoverian and French surveyors as early as 1863, but then the measures taken failed to confirm the opinion which had been previously advanced of the presence of oil. Since 1872 petroleum has been obtained without intermission, although the process adopted for its extraction has consisted in little more than a mere washing of the sand, through which the oil was suffered to run into vessels prepared for its reception.—*Iron.*

[From other sources we learn that this petroleum has the reputation of being inodorous!]

1325. Ingenious.—A German chemist determines by chemical analysis the amount of water evaporated in a steam boiler.

By means of a st ndard solution of nitrate of silver he first determines the quantity of chlorine in the feed water, and then the quantity of chlorine in the water of the boiler at two different times several days apart. From the increased quantity of chlorides he calculates the amount of water evaporated. He recommends as a suitable normal solution of silver to dissolve 23 94 grains nitrate of silver in 1000 cubic centimeters of distilled water. Each cubic centimeter of this solution will precipitate exactly five milligrams of chlorine. To indicate the end of the reaction when all the chlorine is precipitated, he employs the neutral chromate of silver, which produces with any excess of silver solution a bright red color.

1326. New Dredging Process.—Bergeron suggests that deposits of sand and mud in harbors might be cleared away by forcing into them the perforated ends of large tubes, through which a powerful stream of water is forced. The numerous currents would, he thinks, act upon the deposit in the same manner as so many underground springs, washing it away so that the soil could be distributed by the flow of the tides.

1327. Far-Eastern Gas-Coals.—The following extracts from the last report of the engineer to the Singapore Gas Company are not devoid of interest:

"At the end of May 113 tons of Bengal coal were received. Its working with Australian coal was satisfactory. If we can obtain low rates of freight we could draw a portion of our supplies from this source; the price of Bengal coal is rupees 108, free on board, or equal to 21s. per ton, A small sample of other coals from the Straits has been sent to me for testing, and it is stated there is a large quantity from where it was taken. This was tried in actual working; the results were quite satisfactory. I have engaged to take 150 to 200 tons as soon as it can be brought to Singapore. The Japan and Formosa coals are very highly spoken of, but up to the present time I have had no opportunity of trying them. I have no doubt that the Sarawak coal will soon be in the market. As to whether it will be to the advantage of the company to use all Australian coal remains to be proved. The directors may rest assured that in this, as well as in all other matters, the interests of the company will be closely looked after."—*Iron.*

1328. A Reverend Inventor.—We have referred before to the patents of the Rev. G. H. Forbes for gas inventions. They are numerous. We have before us two more, which refer to a third, that we have not seen, on using refuse lime. In one he subjects "the foul lime of gas works in the first instance to a process of dry distillation in a retort or other similar receptacle. When the process of distillation has been carried sufficiently far, I admit the external air into the retort to burn the remaining carbonate of lime." In another he again subjects "the refuse lime of gas works to the process of dry or destructive distillation in a retort, and pass the volatile products of distillation through water into a receiver for the purpose of condensing the vapor of sulphur. I thus obtain sulphur. The gases that remain may then be passed through oxide of iron. I afterwards apply the material obtained by burning the products to the purpose of purifying gas."

1329. Health of Schools.—Now that compulsory education is coming in, this subject will assume, if possible, still greater importance. The crowding, for example, will be greater in proportion to the inadequate ventilation, In New York, the *World*, which has given much praiseworthy attention to the subject asserts that "very few if any of the class-rooms have any efficient apparatus that will give even an ordinary supply of fresh air;" that not a few "are gratuitously supplied with foul air from water-closets, undrained cellars, badly constructed hot-air furnaces, and defective sewer-traps;" or that in the majority the proportion of aerial impurity allowed to accumulate is "hygienically speaking, frightful so contemplate."

In some other of our cities, it is asserted to be even worse.

1330. Praiseworthy, so far as it Goes.—A Jersey city paper tells us that at some color works at Bayonne, on the shore of New York harbor, they "have procured two immense iron tanks for the storage of turpentine. Each tank is about 80 feet in length, of circular form, with a diameter of about 9 feet, and a capacity for the storage of 35,000 gallons of turpentine."

The following added remarks contain, we suspect, irony:

"They have been placed in position on shore about 30 feet back from the dock and 200 from the nearest building. It will thus be seen that if their contents ever should become ignited there will be no obstruction to the view. For the comfort of the timid and nervous it should also be observed that the 'grand tank' is situated nearly half a mile from the immense magazines of the Hazard Powder Company."

1331. Walls of Hospitals.—To avert the permanent infection to which ordinary hospitals are subject, a writer in the London *Builder* suggests that thick glass might be easily and cheaply cemented to the walls. It would be non-absorbent, imperishable, easily cleaned, readily repaired if damaged by accident, and, unlike paper and paint, would always be as good as at first. Glass can be cut or bent to conform to any required shape. If desired, the plates may be colored any cheerful tint. The non-absorbent quality is the most important for hospitals and prisons, and, we should think, is worthy the consideration of architects.

1332. American Fish for Prussian Waters.—Negotiations have been opened for the purchase of Lake Weewanapec, Connecticut Farms, Union county, N. J. The price fixed is $300,000, and the transfer is to be made shortly. The lake covers an area of 200 acres, and is fed by never-failing springs. The purchasers are to use it for the raising of leeches, trout and salmon. It is said that the negotiations are being conducted in the interest of the Prussian government, and that the salmon will be taken to Prussia to stock the rivers of that country.

1333. Artificial Pipes.—J. Fottrell, of Dublin, has patented improvements in artificial stone pipes and tubes, and in the coating or lining thereof to render them suitable for the conduit of alkaline liquids and acid products from chemical manure, and gas works, for sewage, saline liquids, and gas. "For the conduit of gas I line the interiors and ends with a coating of silicate of soda in a crude state by painting such parts with a strong solution of the substance, and allowing it to dry slowly. Any other soluble silicate or aluminate may be employed, or a mixture of them. For the conveyance of sewage, the tubes or pipes should be smoothly turned within, and when so arranged should be coated internally with a thin but perfect layer of bitumen laid on hot, and diluted with some oil in order to lower the fusing point so as to ensure complete union with the bitumen agglutinizing the particles of stone. For acids, the basis of the tubing is composed of one of the following materials: Any sample of burnt clay or shale which is not acted upon by an acid; sea or river sand free from matters soluble in muriatic acid; crushed granite; crushed flints or other forms of silica obtained by heating the flints to redness and quenching in water, when they are readily crushed and powdered; earthy minerals unacted on by acids. Tubes intended for saline or alkaline liquids should be made of burnt clay and bitumen, but pipes of the ordinary composition described in my former patent are likewise serviceable for the purpose.—*London Mining Journal.*

1334. Hydrogen Free from Sulphur.—When hydrogen gas is generated from zinc and dilute sulphuric acid in the usual manner, it frequently happens that the gas contains more or less sulphuretted hydrogen, as indicated by the odor and by its acsion on lead paper. Sulphuric acid is itself reduced to sulphuretted hydrogen by the action of nascent hydrogen, and this often happens when too concentrated acid is employed. Commercial zinc may also contain sulphur compounds, which yield, with sulphuric acid, sulphuretted hydrogen. Lowe mixes with the acid sulphate of copper. This is decomposed by the sulphuretted hydrogen, sulphide of copper being precipitated. A portion of the copper is reduced by the zinc, so that it is necessary to add a little copper solution whenever the liquid loses its blue color. The gas is generated more rapidly.

Organic Matter in Water.

The London *Chemical News*, in reviewing a recent French scientific work, by Henri de Parville, makes the following interesting and suggestive extracts and remarks:

"How does organic matter become dangerous? We must not believe that it constitutes, as is superficially said, a tonic element. The phenomenon is more complex. The organic matter in suspension or in solution creates in the water a peculiar medium, suitable for the development of exceedingly small beings of the genus Vibrio. It is no longer mere water—it is a world of microscopic animals and plants which are born, live, and increase with bewildering rapidity. The Infusoria find in the water calcareous, magnesian, and ammoniacal salts, and their maintenance is thus secure. Drink a drop of this liquid and you swallow millions of minute beings. But there are vibrios and vibrios. There are those which are capable of setting up putrefaction in our tissues. These are our enemies; often our mortal enemies. Let a water be placed in contact with organic remains capable of nonrishing these malignant vibrios, and it at once becomes more dangerous than any poison,"

The author points out that, according to the researches of the late Dr. Calvert, charcoal, lime, and permanganate of potash, contrary to the received opinion, facilitate putrefaction and actually promote

☞ *For other reading matter see page* 10.

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SATURDAY, JANUARY 16, 1875.

WISHING TO MAKE THIS JOURNAL an organ of intelligent discussion to those of our readers who may wish to gain or give information on the subjects to which its columns are devoted, the publishers solicit letters from all among them who make the study of these subjects a pleasure, or a profession.

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FITTING REMARKS.—The *World* says a Boston paper asks "How much cloth is required to make a spirit rapper?" We can't tell the exact quantity until legal measures shall be taken for the close of the imposture, but it is evident that most of the lies wherewith spiritualism is clothed as with a garment are made out of whole cloth.

THE ST. JOHN AND ROCKWELL APPARATUS.

Our readers have had now, with the fine cuts and specifications in this issue, and our previous accounts, as full an array of facts as is needed to enable any one, not already biased, to arrive at a decided opinion regarding these exclusively American inventions.

Especially would we direct attention to the Report made by Professor Chandler; which it is our privilege to present to-day. Its general concurrence of conclusion with that of the Editor, given in our last, is sufficiently apparent.

In this issue we also wind up at last our complete report—complete, and minute, almost beyond precedent—of the Proceedings of the AMERICAN GAS-LIGHT ASSOCIATION in October last; with the memoir, presented by the Editor on the proximate analysis of mixed and impure gases; illustrated, as promised, with some very creditable cuts of different new combinations of apparatus, similar to the one shown to the Association in operation.

These new methods of analysis having been employed by the Editor in testing the efficiency of the St. John and Rockwell apparatus, and obtaining the figures tabulated in the Editor's Report in the last issue (being indeed the first and only known methods of analysis by which such figures could be accurately arrived at)—the association in our columns of the two subjects is altogether appropriate; and each is really requisite, to supplement the other.

We think this a good occasion to take, to renew our appeal—made and repeated before, and now repeated again with the emphasis arising from absolute conviction—to the American gas-profession; to make *Gas-Chemistry*—the knowledge and the application thereof—the chief study of their own spare hours, and the *foundation* of the training of younger aspirants. In that nation which has been the nursery of most of the great arts of civilization, and certainly of the Art and the Science of Gas, so far as its yet infant growth has gone—Great Britain; the grand *practical* truth for which we contend in these columns, that all real progress must arise out of the pursuit of science, has in this present age been vindicated and demonstrated, and is now, at the time I write, absolutely adopted and being put into force. Let our readers ponder the following paragraph, from an editorial article last month, in one of the leading and most sterling practical Journals of England. *Iron*, speaking of special education in chemistry, says, of its own country:—

"Chemistry is felt by those who care for science itself to be the corner stone of the natural sciences, and by those actuated by commercial considerations to be the best-paying investment. In ironworks, breweries, chemical works, dyeworks, and some other manufactories, the presence of at least one chemist on the premises is now considered indispensable; so much greater is the confidence of the modern mind in scientific accuracy than in rule of thumb. This recent revolt against the "practical man" has vastly increased the demand for skilled chemists, and even for persons possessed of a less degree of chemical knowledge. Supply has followed demand, and every smart youth now thinks a knowledge of chemistry indispensable."

Iron has not put *gas-works* in its list; but, both there and here, this is a complexion to which we all must come soon. Those who earliest realize it will have most cause to congratulate themselves in the end.

We may surely point to Wm. H. St. John, as an exemplification of our views. Not a trained laboratory chemist, but employed in a large gas works, he occupied himself in the study of the chemical principles that govern the things around him. He has been chiefly instrumental in bringing into use improvements in *purification* whose results have so far gone beyond all precedent, that gas-engineers are even yet hesitating to accept them, finding them difficult of belief; and which are destined to play a great part in the future. In another branch, that of *condensation*, he has now brought forward a device—figured by us to day—for straining the impurities out of gas by means of those impurities themselves, which, in novelty of principle is startling, and in success of actual operation absolute.

We are sure the time is near at hand when many others of the American gas-fraternity will follow the example of the gentleman we speak of, and when the wheels of progress will have many more such strong shoulders set to them, and will move forward—in that road which we believe to be without an end—in spite of all the traditions, errors and prejudices which obstruct its path, and which will have to "clear the track" or be run down and trodden under foot.

1874:
OUR REPORT OF PROGRESS.

We commenced in the last number some notes on the affairs of 1874 coming within our scope; but had to pass it over to this issue. To proceed now therefore:—

Another important actuality brought forth during 1874 is the creation and success of the first long petroleoduct, such as we have persistently advocated, that of the "Columbia Conduit Company," leading into Pittsburgh from a distance of 40 miles. Of course the litigation in progress cannot but end in the triumph of the public interests, as against railroad monopolists, who can only gain time by their present manoeuvres. We look to a near epoch when most of the oil shall be pumped through an oleoduct to some Lake Erie port, and shipped in bulk cheaply to all parts of America, and the world.

Among the ideas that have decidedly marched onwards during 1874, though not new, there is a much larger number. Those relating to the application of petroleum in gas works merit precedence; but these we are now discussing under another head. Let us here say, however, that the progress now making with this idea is such to justify the hope that something may now be done quickly to decide the whole thing by exact scientific chemical tests, by skilled and responsible scientists; instead of its being left altogether in empirical and irresponsible hands, as has hitherto been chiefly the case.

Indeed, it is quite time that we speak our whole mind on this subject, as as on some others: and the chief of our mind is this, that the gas profession must insist on exhaustive *chemical tests* being applied at once, in every case of an alleged improvement, by chemists of proved skill and reliability; and when these tests are obtained, if favorable, they must be *acted upon*, without doubt, hesitation, or procrastination; in spite of prejudices, traditions, or professional authority and conservatism. Thus only will they avert dangerous dissatisfaction and organized interference with their affairs on the part of the public. We urge again, as we have urged, on the Committee appointed to investigate the special subject of petroleum gas at the late Association meeting, that they insist on the parties interested in convincing them, instituting immediate scientific tests. This is far more important for the good of all concerned, than the settlement of

disputes as to priority in filing patent specifications, or as to who shall have the shells of the oyster after the lawyers have had their fill of it. Let us first see exactly what the bivalve has inside of it.

Mechanical stoking, so far as we are advised, does not yet get on very fast with us, but we nevertheless hear, from a reliable source, that one trial is soon to be made, on a great scale, at the New York Gas-Works, of the splendid Rowland system, illustrated and described by us long since.

Another thing that has made progress during 1874, only as an idea, with us, but as an important actuality abroad, is ammonia-saving, or rather making their ammonia profitable to gas companies, not only to outside parties. This is one of those large subjects which we are making preparations to take up in earnest and thoroughly at an early day, and shall therefore let it now rest for the present. In some measure connected with it, as we shall show, is Chemical Insecticide, which has made great and successful strides during 1874, especially in France. This we also defer.

Naphthaline has begun to receive study during 1874; at least the importance of its chemical study is beginning to be well appreciated by all; and it is therefore to be hoped that the management of this beautiful nuisance may not be much longer left to guesswork, but that its investigation may be put into the hands of competent chemists to discover and specify the exact conditions and causes of its formation and condensation. Unquestionably, if separated from the gas and saved, it would be found a highly valuable "residual," instead of being, as now, far worse than worthless.

Another ancient idea—one supposed to have been long since "exploded" in England, but which we Yankees have been crazy enough to revive and revivify—is the making of "water-gas," and the using of it as a vehicle for illuminating hydrocarbons. The Report of the five-months chemical investigation of Silliman and Wurtz, made at Fair Haven six years ago, has been in 1874 for the first time put before the world—having been, we may here state, copied in full also from this Journal into the London *Journal of Gas-Lighting*. The statement of the authors of this report, as to the actual *cost per thousand feet*, of the mixture of two volumes of hydrogen with one of carbonic oxide, as between twenty-eight and twenty-nine cents, has been confirmed by the work of Captain White of the Brooklyn Citizens Company, who comes considerably within this figure. Silliman and Wurtz, however, allowed $8 per ton for anthracite, and so on for all the items, in order to be far on the safe side. The cost, on a manufacturing scale, of making purified water-gas (containing not over five per cent. of nitrogen) by the American method, may now be reasonably put at twenty cents per thousand feet. This looks like progress. Let us now know quickly. When the world has definitely before it so huge an element of progress as this, why should there be such interminable and pusillanimous delays in taking hold of it? Future generations will scoff at us unless we mend this.

Among the details yet to be wrought out, in connection with this water-gas, is one to which we referred in an editorial of Dec. 16—the result of combining it with petroleum-gas, etc., which seems to have had some darkness shed upon it by the results at the works of Captain White. Let us have *light*, and at once.

As regards retort-house affairs during 1874: Progress has been made with the Gibson and Jones plans of working retorts with valves; as has been recorded by us, so far as transmitted. Ten per cent. gain over the ordinary hydraulic seal is, we believe, a conceded general result. Mr. McIlhenny's system also continues to work to exceeding satisfaction in Washington, Portland and elsewhere, and we are surprised not to hear of its introduction widely throughout the land.

Sunday Rest, and the keeping in Gas-Works of the Fourth Commandment of the Mosaic Law—recognized, in theory, by Jew and Gentile—is another idea, in the introduction and appreciation of which, in America, some progress has been made during 1874. We have not yet heard of any actual new results among us, though there may have been such. The good seed, however, has been sown, and will spring up and fructify.

There are a number of other important matters, in which progress is being rapidly made abroad, but in which we, on this continent, are as yet altogether supine. Gas-Motors is one. The state of things in this regard, in the French capital, it will be wholesome for us to note, as recited in the admirable article on Gas in Paris, which we reproduced in our last issue, from that excellent journal, *Iron*. Cooking and Heating by Gas, also, make as yet substantially no progress with us.

Gas-Purification, to remove the sulphur in gas in *latent* forms, that is, not answering to the common lead-paper test, is a topic that has scarce been awakened at all as yet, on this side of the Atlantic. We shall now but drop the hint that when these things came to be looked into, the amount of this latent impurity, which the testimony of the nose scarce touches, yielded by some of our favorite American gas-coals, will be found to surprise us all. An awakening will come, in spite of us; and, if wise, we will be found prepared for it. The amazing fact, unknown and incredible to the general public, that there are scores of huge and rich companies in these United States, that *employ no chemist or chemical analyst* or *adviser*, must soon be mended. It would tell in the wrong direction, and we should not even undertake to say that *stocks* might not be affected.

Big Enterprise.—Lloyd, the famous map man, who made all the maps for General Grant and the Union army, certificates of which he published, has just invented a way of getting a relief plate from steel so as to print Lloyd's Map of American Continent—showing from ocean to ocean—on one entire sheet of bank note paper, 40 × 50 inches large, on a lightning press, and colored, sized and varnished for the wall so as to stand washing, and mailing anywhere in the world for 25 cents, or unvarnished for 10 cents. This map shows the whole United States and Territories in a group, from surveys to 1875, with a million places on it, such as towns, cities, villages, mountains, lakes, rivers, streams, gold mines, railway stations, etc. This map should be in every house. Send 25 cents to the Lloyd Map Company, Philadelphia, and you will get a copy by return mail.

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THE ANNUAL MEETING OF THE ASSOCIATION WILL be held at the **TREMONT HOUSE,** Boston, on THURSDAY, February 11, 1875, at 12 o'clock, Noon.

374 GEORGE B. NEAL, Secretary.

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the formation of animalculæ. Charcoal when used for the purification of polluted waters, undoubtedly absorbs into its pores offensive gases held in solution, as well as liquid coloring and flavoring matters. It can render such waters colorless and tasteless. But upon living animalculæ and their germs it is absolutely powerless. Nay, water containing a known amount of "albumenoid ammonia" when experimentally filtered over animal charcoal has been found on analysis worse than before. Permanganrte of potash may oxidise—in fact, burn up—dead organic matter suspended or dissolved in water; but upon living organisms it is almost powerless. We have seen animalculæ remain in full life and apparent vigor for hours in water to which permanganate had been added in a large proportion. M. Davaine found that putrid blood after treatment with charcoal became more putrid than before It is possible that the gases dissolved in the liquid hinder the development of the Infusoria. The author considers carbolic, or better still cresylic acid, as the only agent which extirpates these animalcules. According to Woehler, alumina in the gelatinous state precipitates the dissolved animal matter which serves as a pabulum for these minute animal and vegetable beings. The experiments of M. Davaine on the power of antiseptics to destroy the virus of carbuncle belong rather to medicine than to chemistry. Solution of iodine seems the most effectual remedy.

The Age of Coal.

It seems probable that vegetable matter may, under favorable conditions, be converted into coal much more rapidly than geologists are in the habit of assuming. A curious instance has been brought before the German Geological Society by Herr Hirschwald, of Berlin. In the Dorothea mine, near Clausthal—wood originally employed as timbering has become so far altered as to assume most of the characters of a true lignite, or brown coal.

It appears that certain of the levels in the ancient workings of this mine are filled with refuse matter, consisting chiefly of fragments of clay slate, more or less saturated with mine water, and containing here and there fragments of the old timbering. This wood, when in the mine, is wet, and of a leathery consistence, but on exposure to the air it rapidly hardens to a solid substance, having most, if not all, the characters of a true lignite. It breaks with a well-marked conchoidal fracture, and the parts which are most altered present the black lustrous appearance characteristic of the German "pitch-coals." At the same time, chemical examination of the altered wood shows that it stands actually nearer to true coal than do some of the younger tertiary lignites. This instance seems, therefore, to prove that pine-wood when placed under highly favorable conditions, may be converted into a genuine lignite within a period which, from what we know of the history of mining in the Hartz, cannot have extended beyond four centuries.—*Athenæum, London.*

To Render Glass Opaque or Frosted.—According to *Dingler's Journal*, a sheet of ordinary glass, whether patent plate or crown does not matter, is cleaned; and if only portions of it are to be frosted, those are left bare, while the others are protected by mechanical means in any simple manner. Some fluor spar is rubbed to a fine powder and mixed with concentrated sulphuric acid, so as to make a thin paste, and this is then rubbed by means of a piece of lead upon those parts of the glass required to be rendered opaque. A fine frosted outline or design may thus be produced upon a sheet of smooth transparent glass. To finish the operation, the glass is gently heated in an iron vessel covered with a funnel passing up the chimney, to get rid of the noxious fumes that are given off; on cooling, the plate is washed with a dilute solution of soda or potash, to remove any acid yet remaining, and is then rinsed in water. Focusing glasses for the photo camera, and development glasses for pigment printing, can be prepared in this way at very little expense.

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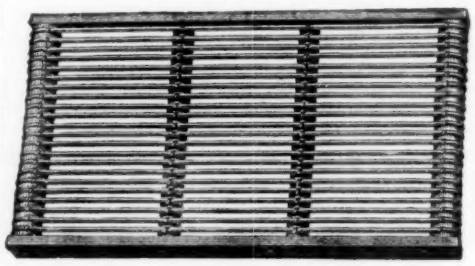

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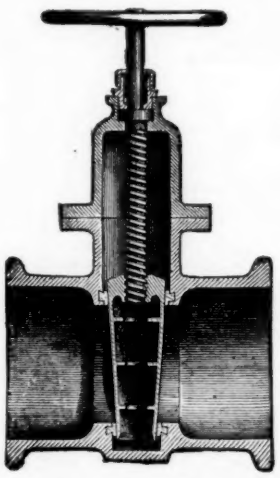

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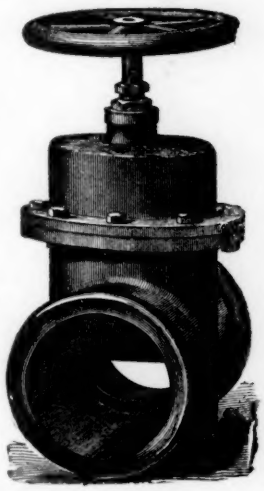

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Many Bostonians had to return to town last summer from the delightful health resorts about the Hub in order to have their typhoid fever treated by their family physicians.

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MADE FROM BEST MALLEABLE IRON AND STEEL

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Perfect in their operation, a very strong, and from their great durability vastly more economical than any substitute. Refer to all the principal gas Companies in the country, who acknowledge them as the "ne plus ultra of Coke Screening Shovels.

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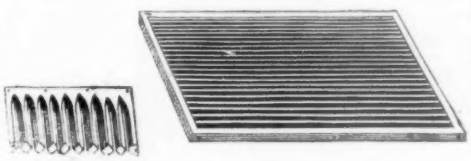
PATENTED OCTOBER 21, 1862 AND JUNE 10, 1873.



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A YOUNG MAN OF LIBERAL EDUCATION, WHO HAS spent many years in the study of gas, and working in a large gas works, desires a situation as Superintendent of a works making 10,000 to 50,000 cubic feet daily. Has good reference as to ability; or would act as Assistant in large works. Would prefer a situation on the staff of a gas works builder—draws well, and has experience in setting up apparatus. Address, stating salary, C. P. V., care of W. B. CARPENTER & Co., Cincinnati, Ohio. 372

$30 per Dozen.

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FOR COKE, COAL, ASHES, AND OTHER SUBSTANCES.

The frames are 12 by 18 inches, with seven bars, and are made of the best malleable Iron. They can be wired between bars by an arrangement of holes a quarter of an inch apart, by an ordinary person, to screen any size substance desired. They are warranted to be the most durable and practical Screening Shovel made, or money refunded.

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The Mackenzie Patent Gas Exhauster

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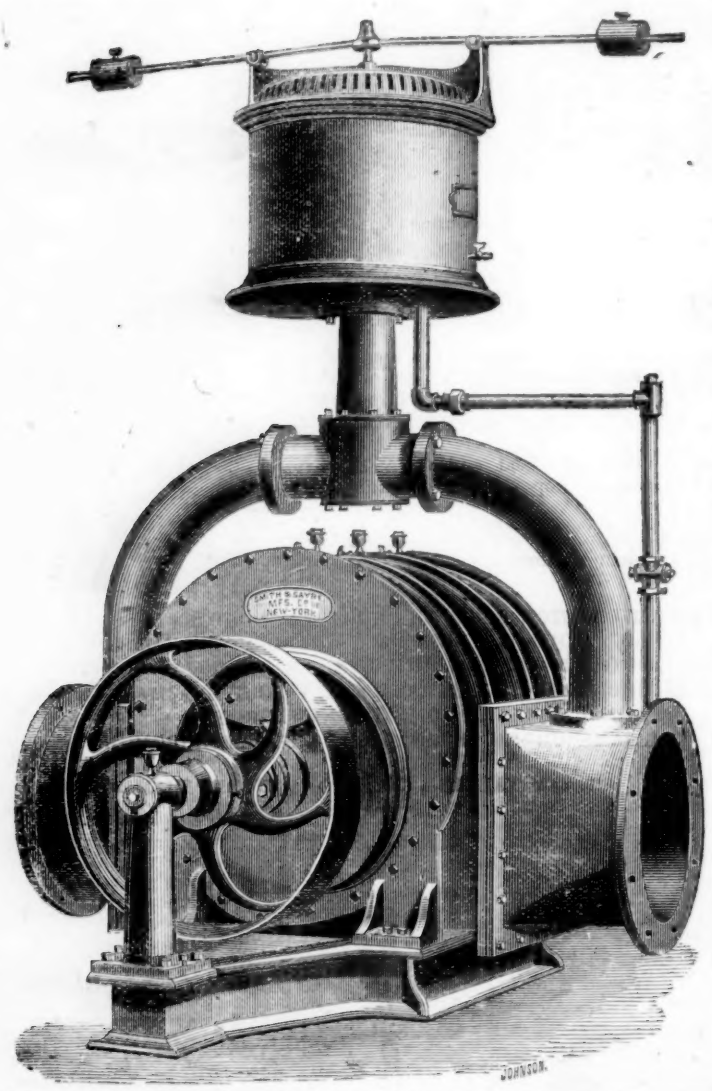

They are made to pass from 4,000 to 150,000 cubic feet of gas per hour; will increase the production and illuminating power of the gas, and add very much to the durability of the retorts, either clay or iron. The Compensator obviates entirely the necessity of water-jo ints, is compact, durable, cleanly, not liable to get out of order, self-acting, quiet, and certain in its operation.

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The Blower is a Force Blast machine, durably built, and can be driven with one-third the power required to drive the ordinary fan. The Cupolas are manufactured in sizes to melt from 1 to 90 tons per hour, will save one quarter of the time required by the old style Cupola and 33 per cent fuel. Address

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[Reported Expressly for this Journal.]

JANUARY 16, 1874.

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Ince Hall	$17 00	@	18 00
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Newcastle Gas	$12 00	@	00 00
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British Province Coals.			
Picton	2 50		
Block House—At Mines, $2 12, Gold	0 00		
Caledonia—At Mines, $2 00, Gold	0 00		
Little Glace Bay—At Mines, 1 87½, Gold	2 00		
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MurphyRun	$7 40	@	0 00
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West Fairmont	7 40	@	0 00
American Gas Coal	7 40	@	0 00
Fairmont	7 40	@	0 00
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" —at South Amboy			9 00
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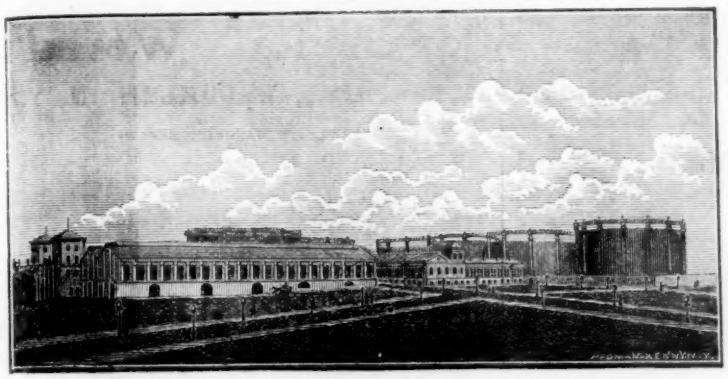

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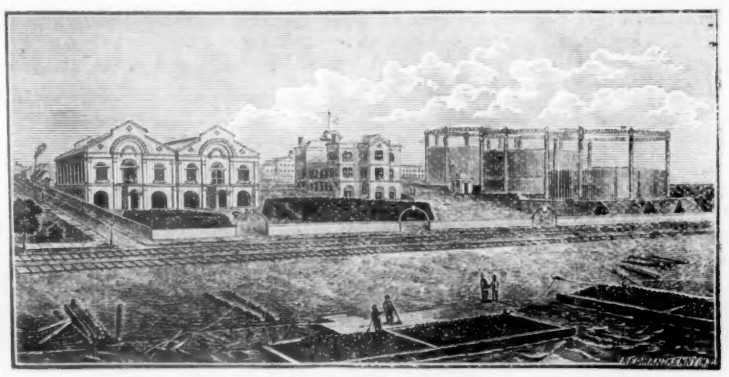

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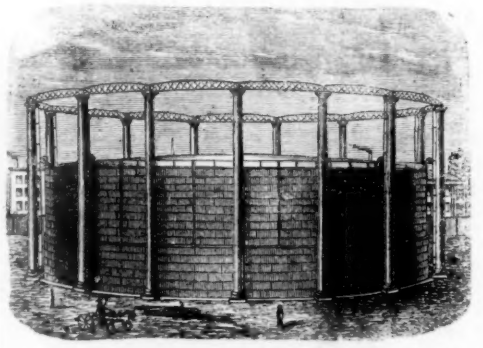

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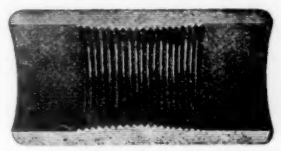

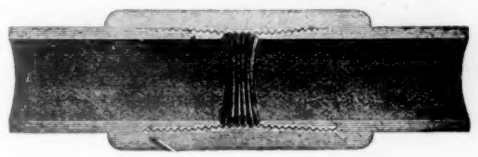

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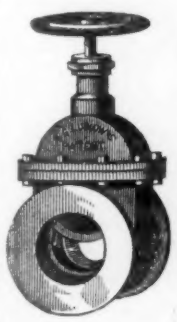

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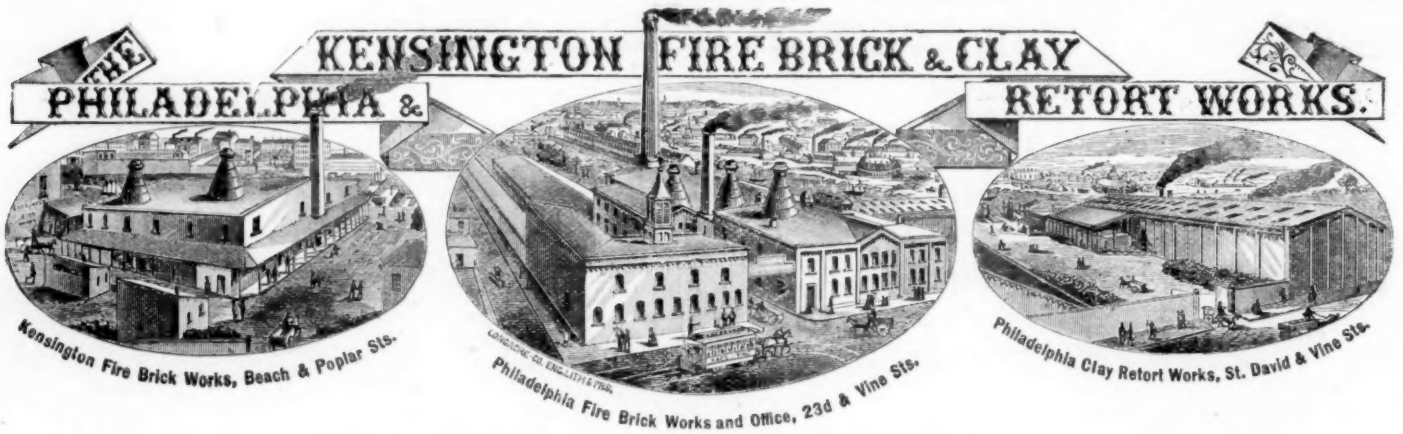
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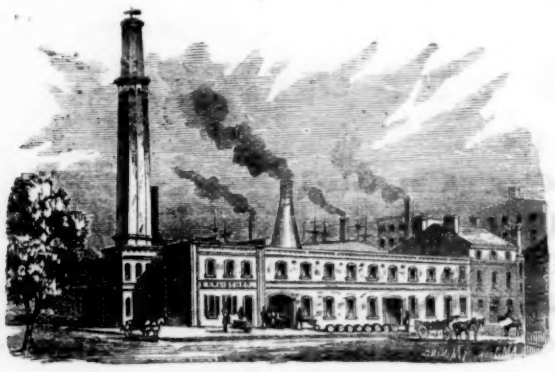

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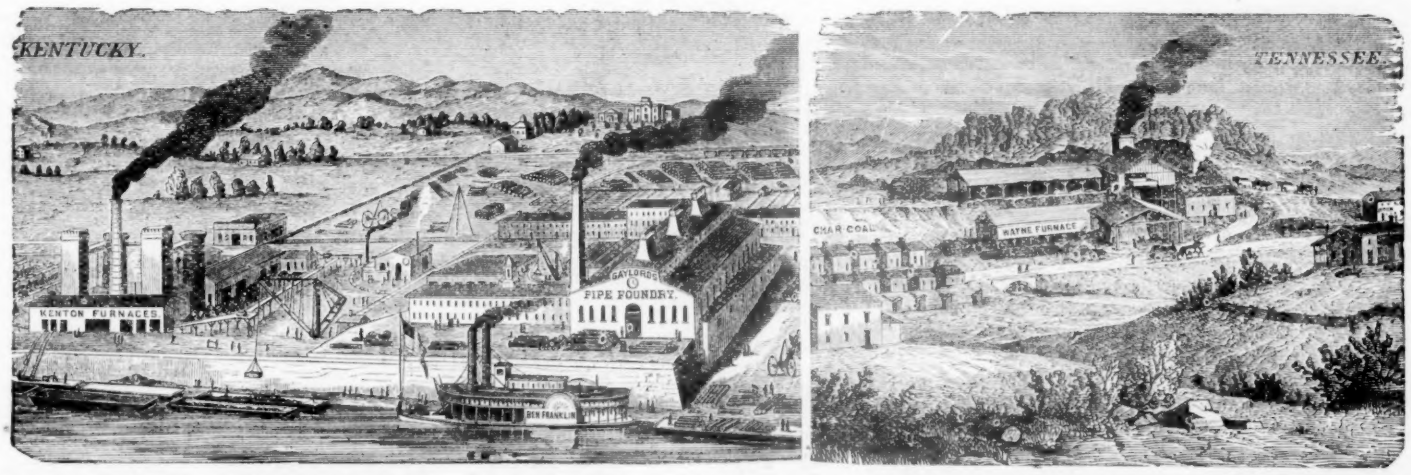

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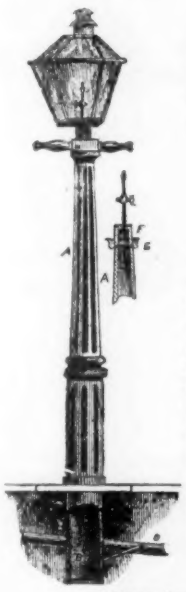

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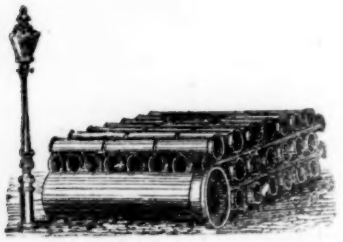

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The process can be put into either Coal or Oil Gas Works (or where both Coal and Oil are used) at small cost, without any interruption to the working of other benches. The Citizens Gas-Light Company of Brooklyn, after using it for more than seven months, have found it not only far better, but actually *cheaper* than atmospheric air in making Gas, with the use of "petroleum and its products."

Further information, and terms of sale of rights will be given, upon application to the Company 348-1y

MURRAY & BAKER,

Practical Builders.

And Contractors for the Erection of Gas Works,

MANUFACTURERS OF ALL THE LATEST AND MOST IMPROVED APPARATUS AND TOOLS FOR THE MANUFACTURE & DISTRIBUTION OF COAL GAS.

☞ WORKS AT THE RAILWAY DEPOTS,

FORT WAYNE, INDIANA.

We manufacture Bench Castings, Washers, "The Immersed Multitubular," and Atmospheric Condensers, Wet and Dry-Lime Purifiers, Dry Center Seals, Telescopic and Single Gas Holders, Wrought Iron Trussed Roof for Iron or Slate; Wood and Iron Trays for Purifiers, Coke and Coal Carts, Wrought Iron Screening Shovels and Castings, and Wrought Work of every description for Gas-Works.

As Mr. Murray is a Practical Draughtsman, we will furnish plans and specifications to parties or associations, or will wait personally upon parties contemplating the construction of new works, or the alteration or extension of old ones

The most satisfactory references can be given, if required of the experience and commercial fairness which characterizes our dealings.

We would respectfully invite Western men to call and see our patterns and works here. MURRAY & BAKER,
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Of Cleveland, Ohio.

AND SHIPPER OF THE CELEBRATED AND ONLY GENUINE

Sterling Coal,

also dealer in YOUGHIOGHENY, PITTSBURGH, AND AMERICAN CANNEL. Would refer to the following Gas-Light Companies, who have used the HAND PICKED SELECTED COAL:

New York City, Manhattan and New York Companies, Brooklyn, Albany, Troy, West Troy, Rochester, Buffalo, Osgo, Ogdensburgh, Lansingburg, Newburg, Rome, Pai- Geneva, Yonkers. Rondout, Kingston, Albion, Brockport, Seneca Falls, Elmira and Lyons, n State or New York; Cleveland, Toledo, Sandusky, Norwalk, Oberlin, Salem and Fremont in Ohio; Detroit, Ann Arbor, Grand Rapids, Kalamazoo, Jackson and Adrian, in Michigan; Toronto, Hamilton, and Coburg, in Canada; Chicago, Ill., and two Companies in Milwaukee, Wisconsin.

Letters in reference to Coal should be addressed to the General Office of FREEMAN BUTTS, Cleveland, Ohio. 354

THOMAS T. TASKER JR. STEPHEN P. M. TASKER.

MORRIS, TASKER & CO.,

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Established 1821.

FOR GAS WORKS MACHINERY, ADDRESS OFFICE FIFTH AND TASKER STREETS, PHILADELPHIA.

Manufacturers and Builders of Gas Works, &c., of all Descriptions, of the Most Approved Plans.

WROUGHT IRON ROOF FRAMES.—For Slate, or Corrugated Iron Coverings, with Cast Iron Cornice Gutter. Iron Doors and Frames, Wrought Iron Pivot Blinds, Windows and all kinds of Castings and Smith Work for Buildings.

BENCH CASTINGS.—Retorts, and all Castings and Wrought Iron Work required for Setting them on the Latest Plan. Tar Gates, Wrought Iron Stand Pipes, Retort Lids, Cotter Bars, Coal and Coke Wagons, and Stokers' Tools.

EXHAUSTERS.—Exhausters and Compensators, By-Passes to pass from 4,000 to 150,000 Cubic feet of Gas per hour, with Engines, Governors, Pressure and Vacuum Guages.

SCRUBBERS.—Single or Multitubular Scrubbers, with Self-Acting Pumps for Ammonia Water.

WASHERS.—Cataract and Single and Multitubular Spray Washers.

CONDENSERS.—Single and Multitubular Air and Water Condensers.

PURIFIERS.—For Purifying from 1,000 to 2,000,000 cubic feet capacity daily, with either wet or dry Lime, or Oxide of Iron, and with either Ash Rivetted or Wrought or Cast Iron Lime Sieves.

CARRIAGES.—Movable Lifting Carriages for Purifiers, arranged either for Floor or Overhead use.

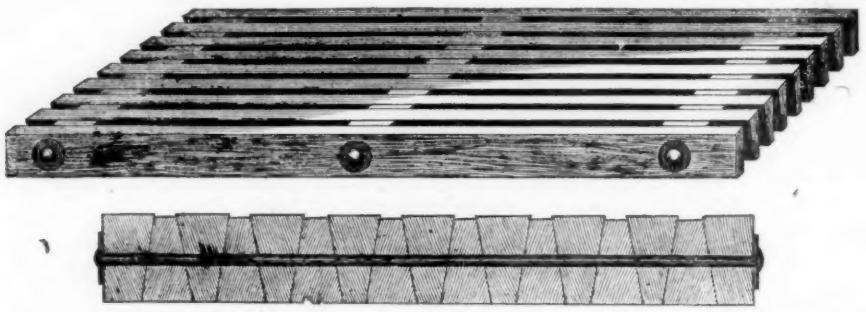
METERS.—Square and Round Meters of any capacity.

GAS HOLDERS.—Single Lift and Telescopic Gasholders, with Cast or Wrought Iron Suspension Frames.

GAS GOVERNORS.—Station Governors, with Regulating and Indicating Columns for Inlet and Outlet Pipes, also Dry Governors with Flexible Diaphragms for Underground Pipes.

STOP VALVES.—Double Faced Stop Valves for Gas or Water, from three inches to forty-eight inches diameter. These Valves are proved on both sides, with a heavy Water Pressure, Flange and Bell Pipes, Fittings and Drips of all descriptions. Steam Boilers and Hot Water Apparatus for Heating Building, and Gas Holder Tanks. Lamp Posts and Lanterns.

P. Munzinger's Patent Ash Lime Trays.



In use at the following Gas-Light Companies:

Pittsburg Gas Company, Pa.
Peoples Gas Company, Baltimore.
Lowell Gas-Light Company, Mass.
Lynn Gas-Light Company, Mass.
Albany Gas-Light Company, N. Y.
Schenectady Gas-Light Company, N. Y.
Utica Gas-Light Comwany, N. Y.
Jersey City Gas Company, N. J.
St. Paul Gas-Light Company, Minn.
Cumberland Gas-Light Company, Md.
Hartford City Gas-Light Company, Conn.
Richmond Gas Company, Va.
McKeesport Gas Company, Pa.
Middletown Gas Company, Pa.
East Newark Gas-Light Company, N. J.
Binghampton Gas Company, N. J.
Zanesville Gas Company, Ohio.

New Orleans Gas Company, La.
Salem Gas-Light Company, Mass.
New Britain Gas-Light Company, Conn.
Rahway Gas-Light Company, N. J.
Trenton Gas-Light Company, N. J.
Elmira Gas Company, New York.
Erie Gas Company, Pa.
Columbus Gas-Light Company, Ohio,
Westchester Gas-Light Company, N. Y.
Santa Cruz Gas Company, Cal.
Lawrence Gas-Light Company, Kansas.
Salem Gas Company, N. J.
Indiana Gas-Light Company, Pa.
Peoria Gas Company, Ill.
Montclair Gas Company, N. J.
Williamsport Gas Company, Pa.
Wooster Gas-Light Company, Ohio.

Augusta Gas-Light Company, Ga.
Huntsville Gas Company, Ga.
Chattanooga Gas Company Tenn.
Murfreesboro Gas Company, Tenn.
Hagerstown Gas-Light Company, Md.
Hanover Gas Company, Pa.
Easton Gas Company, Pa.
Uniontown Gas-Light Company, Pa.
Coatesville Gas-Light Company, Pa.
Houston, Gas Company, Texas.
Wilkesbarre Gas Company, La.
Middletown Gas Company, New York.
Washington Gas-Light Company, Pa.
Princeton Gas-Light Company, N. J
Newark Gas Company, Ohio.
Pontiac Gas-Light Company, Mich.
And numerous other Companies.

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